



MDA/MP Radar & RF Insertion



August 2005

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MP MISSION AND FUNCTIONS

Mission Statement

- Responsible To The Director, MDA For BMD System-Wide Producibility And Manufacturing Risk Assessment, Mitigation, And Applications

Functions

- Assess Priority BMDS Risks Related To Producibility, Manufacturing, Quality, Cost, And Schedule
- Assess MDA Technology Programs Applicability To BMDS Needs And Readiness for Transition
- Assess And Report Transition Readiness Using Engineering Manufacturing Readiness Levels (EMRLs) And The Appropriate EMRL Exit Criteria Metrics (CKP) In Concert With The Elements
- Coordinate MDA Industrial Base Policy And Investments
- In Concert With The Elements, Develop Industrial And Manufacturing Investment Strategies For System Affordability And Insertion Of Successive New Capabilities



Innovative Radar RF Sensors and Signal Processing

- Provide subsystem improvements to enhance BMDS radar performance and sensitivity for emerging threats:
 - Demonstrate producibility and reliability of high-power amplifiers (e.g., SiC, GaN, and High-Voltage GaAs).
 - Introduce producible materials and technologies to enhance thermal management.
 - Improve manufacturability of T/R Modules and TRIMMs for cost and schedule.
 - Introduce “Open System” approaches and architecture to prevent parts obsolescence and stimulate competition at the subsystem level.
 - Introduce composite materials to reduce antenna weight, improve transportability.
- Core programs
 - RF Micro-electronics packaging
 - Wide Bandgap Program
 - High Voltage GaAs
 - WBG reliability test Program
 - Hybrid Opto-Electronic Signal Processor Maturation and Evaluation



Innovative Radar RF Sensors and Signal Processing

- **MDA/MP is engaging with Program Offices to identify technology areas of concern**
 - Focus on SBIR tasks that improve capabilities within 1 to 3 years
 - Continual process
 - Identify new processes
 - Identify new technologies
 - Provide solutions to technology problems
 - Prime and Second and Third Tier contractors are working with us on implementation
- **MDA/MP support of BMDS RADAR acquisition aimed at**
 - Near term technology insertion with demo of producible technologies
 - Tie-in with MDA Primes and 2nd/3rd tier suppliers
- **Program support with core MP funding / SBIRs / STTRs**
 - Device development (WBG, High voltage GaAs)
 - Packaging / Thermal management
 - Reliability testing
 - Product maturity (EMRLs)



MDA/MP Focus

- MDA System/Subsystem Near Term Spiral Development
 - Potential for Near-Term Insertion (1-3 Years)
 - EMRL of 3 or higher
 - Demonstrated Capabilities for Multiple Applications
 - Common Components
 - Demonstrate Producibility
 - Best Industry Practices
 - Foster Tie-in with MDA Primes or our large 2nd and 3rd Tier Suppliers
 - Near Term P3I
-

- Modular Designs for Future Systems

Focus on Leverage / Cost Sharing / “ Long Poles”



Innovative Radar RF Sensors and Signal Processing – Core Programs

- **Technical Evaluation of Packaging Technology for T/R Modules for Phased Array Radar Systems**

- ONR Contract with: ACI MANTECH Center
- Goal – Technical evaluation of available packaging technologies for phased array radar system T/R modules.

- **Sub Ambient Cooling System (SACS)**

- SMDC BAA Contract With: Touchstone. Touchstone funding Raytheon for system development
- Goal – Develop and test proof of concept High heat flux sub-ambient cooling system for Radar T/R integrated modules.

- **Silicon Carbide (SiC) MMIC Producibility Enhancement Program**

- ONR Contract with CREE Research
- Goal – Establish a foundry capability for affordable, reliable, high-performance SiC based devices and MMICs for BMDS Radars

- **High Voltage GaAs Producibility Program**

- ONR Contract with Triquint, Inc.
- Goal – Develop high voltage, high power density, X-Band pHEMT devices and MMIC amplifiers

- **RF Device Reliability Test Program**

- NRL Reliability Testing Program
- Goal – Independent DoD reliability testing/verification of power amplifier discrete devices, MMICs and packaged transmit/receive modules.

- **GaN Epitaxy Producibility Program**

- Contract TBD FY06
- Goal – Develop a producibility program for GaN epitaxial layers used for BMDS X-band radar power amplifier discrete devices, MMICs, and packaged transmit/receive modules.

- **Advanced Optical Processor (AOP) Lexington Development (LexDev) Interface test and ALCOR operational test.**

- NAVAIR Contract with: Essex Corp.
- Goal – Prove operation and data collection by testing the AOP while installed in the LL/MIT LexDev. Operational data collection and analysis with AOP installed in ALCOR on Kwajalein Atoll.

- **Sub Ambient Cooling System (SACS)**

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MDA/MP MAJOR ACCOMPLISHMENTS

- Major Player In MDA's SBIR Program To Enable More Rapid Transitions Of New Capabilities
 - 02.1 Announcement: 55 Phase I Awards, 29 Phase II Invitations Supported By MP
 - MP Topics In 02.2 Announcement: 51 Phase I Awards
 - Follow Up On 55 Phase II Initiatives Putting Many Small Firms In Direct Contact With Primes
 - MP Awarded The First Phase III At MDA (AOP)
 - Phase III recently awarded to V Systems
 - Network Of Primes And Major Subcontractors Established To Promote Relationships And Provide Opportunities With Small Businesses
- MP Furnishes Leadership, Seed Money, Cost Sharing And SBIR Strategy To Promote Producibility, Manufacturability, And Affordability Goals

Activities Are Paying Off With Selected SBIR Companies Making Prototype Hardware For SM-3, THAAD, And EKV



MDA Radar Stakeholders

MDA/SN

Focus: Acquisition

- ▶ Acquires Radars for BMDS
- ▶ Evolutionary Improvements, Near-Far term focus

MDA/AS

Focus: Technology Development

- ▶ Break through technology/Concepts
- ▶ Far-term focus

MDA/MP

Focus: Technology/Product Producibility and Insertion

- ▶ Demonstrate Producibility and Insertion of new Technology/Products
 - RARST Legacy
- ▶ Near-Mid term focus



Technology Insertion Candidates

- Wide Band Gap (WBG) High Power Amplifiers—Reliable SiC, GaN, and High Voltage GaAs Amplifiers for 2x-5x Performance Enhancement
- Advanced Thermal Management--Supports Higher RF Peak Power Levels using Active (2-Phase)/Passive(Pyrolytic Graphite)
- New Architectures for Antenna Hardware—Alternative T/R Module/TRIMM designs/Antenna Structure to Lower Production Costs and Weight (EnhanceTransportability)
- Open Systems Architecture for Backend Electronics--Fosters COTS utilization, Object Oriented Software, Flexible Waveforms and Innovative Signal Processing
- Signal Processing Improvements—New Optical Processor for Real Time High Instantaneous Bandwidth Signal Processing

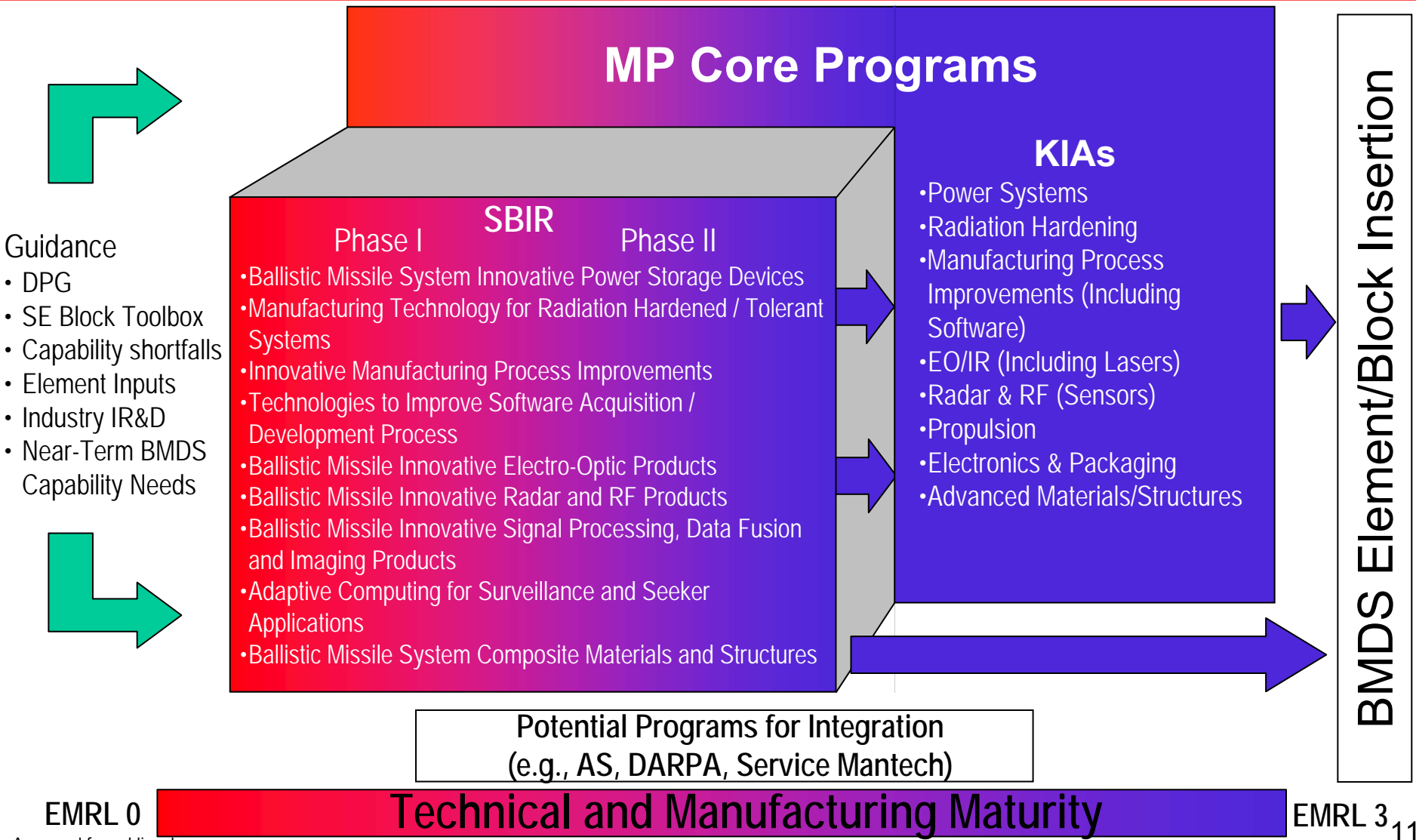


Utilizing Small Businesses

- MP Has as Excellent Track Record of Involving Small Business with Raytheon, Lockheed-Martin, Northrop-Grumman and other Major Companies in a number of Vital Areas (e.g., Industry Days)
 - High Power Amplifiers
 - Advanced Thermal Management
 - Alternative Packaging Techniques
 - Light-Weight Antennas/Heat Exchangers
 - Alternative T/R Module/TRIMM Designs
 - OS Approaches to Backend Electronics
 - Waveform Agility (PRN/Chaotic Codes)



Key Investment Area (KIA) Process





Industry Days



MDA/MP Industry Days

•As of August 2005 a total of Sixteen Industry Day Events have been held

- The First Three were held in Crystal City, VA
 - February 2003, April, 2003 & May 2003
- Nine have been held at Prime Contractor Facilities
 - June, 2003: Raytheon IDS, Andover, MA
 - July, 2003: Raytheon Missile Systems, Tucson, AZ
 - September, 2003: Lockheed-Martin MFC, Dallas, TX
 - November, 2003: Lockheed-Martin NESS, Moorestown, NJ (in cooperation with NSWC-Crane)
 - December, 2003: Lockheed- Martin MFC, Orlando, FL
 - May, 2004: Lockheed-Martin, Sunnyvale
 - May, 2004: Raytheon, Tucson
 - June, 2004: Raytheon APC, Dallas, TX
 - October, 2004: Raytheon IDS, Woburn, MA
 - July 2005: Boeing, Anaheim, CA
 - August 2005: Northrop-Grumman, Baltimore, MD
 - August 2005: Sensis Corporation, Syracuse, NY
 - August 2005: Lockheed-Martin, Syracuse, NY

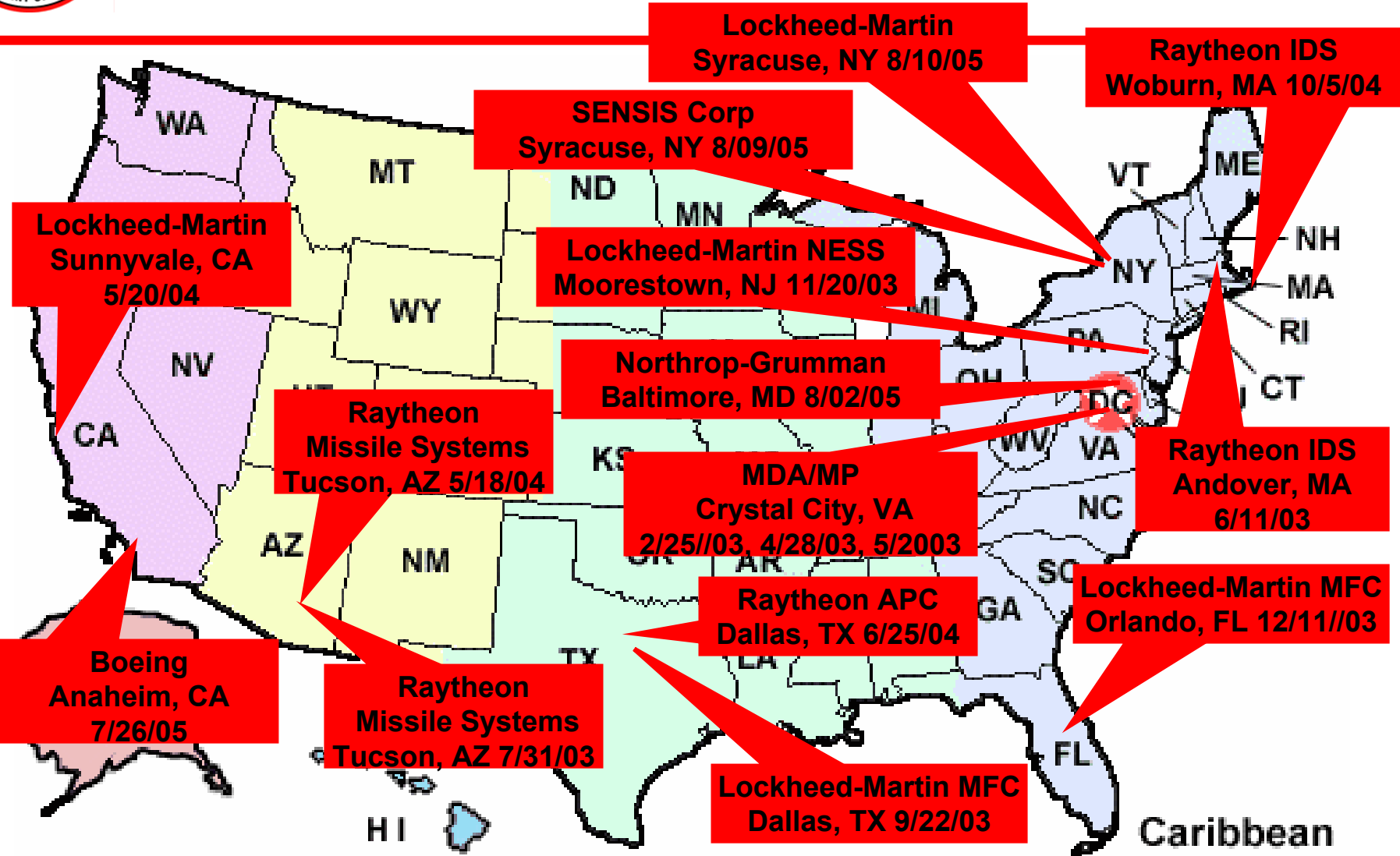


MDA/MP Industry Days Successes

- **Industry Day has resulted in several significant events**
 - **Co-operative Agreement between Raytheon, Andover and Epitaxial Technology, Inc. (Baltimore, MD) for fabrication and testing of InP based HEMPTs**
 - **Adoption of MDA/MP industry Day format by AFRL, Kirkland AFB for SBIRs supporting ABL**
 - **Adoption of MDA/MP industry Day format by MDA/AS**
 - **Consideration of MDA/MP Industry Day format by the Chief Scientist MDA for use for an MDA wide Industry Day**
 - **Co-operation with NSWC Crane for inclusion of SBIR companies sponsored by MDA two-letters other than MP**
 - **Open discussions between numerous MP Sponsored SBIR companies and the prime contractors**
 - **Repeated interest in Thermal Management topics by the primes, Contracts with MMCC (Woburn, MA), Vanguard (Anahiem, CA), San Diego Composites (San Diego, CA)**
 - **Discussions between Harmonia and Raytheon, IDS for legacy software translation and re-use.**



MDA/MP Industry Locations





RF Micro-Electronics Packaging



RF Micro-Electronics Packaging Study

- MP Program Objectives
 - Investigate State of the Market for RF Packaging Technology
 - Pursue COTS based solutions where possible
 - Investigate Existing and New RF Module Technologies
 - Evaluate Electronic, Thermal Management, RF, EMC, Cost and Producibility of each Technology/Combination of Technologies considered
- Results
 - Identified and evaluated candidate materials for high density, moduleless T/R module designs
- Insertion: Generally applicable to all Radar Systems



WBG Materials Program



Silicon Carbide (SiC) MMIC Producibility Enhancement Program (CREE)

- Joint Program with DARPA
- MP Program Objectives
 - To establish a foundry capability for affordable, reliable, high-performance SiC-based devices and MMICs for BMDS Radars. Cost Goal: \$10/mm. BMDS benefits include: 1, increased power (increased radar capability); 2, use less modules for same power, significant cost savings; and 3, use current power levels with same number of modules, resulting in increased life cycle reliability.
- Insertion: Navy AEGIS Radar (SiC), BMDS X-band Radars (GaN on SiC Substrate)
- Achieved 3" high purity, semi-insulating SiC substrates; Need 4" for GaN implementation for BMDS X-band radars (cost driver)
- 2006 Program Completion



Semi-Insulating SiC 4-inch Diameter Producibility Program (II-IV, Inc.)

POC: John Blevins; (937) 255-4474 X3210; John.Blevins@wpafb.af.mil

- Program Objectives

- Producibility program for 4-inch diameter semi-insulating SiC wafers used for power amplifier discrete devices, MMICs, and packaged transmit/receive modules. Develop multiple sources for SiC substrates. Three year program with Government cost goal of <\$1,000/wafer.

- Results

- Nominal boule diameter for 6H and 4H crystals has been expanded to 4 inches with 3.5 inches useable area.
- Vanadium doping for 6H has been optimized.
- Q1 efforts yielded SiC substrates with micropipe density of 40/cm² (hero) and 60-70/cm² (typical) for 3.25 inch 6H.

- Insertion: BMDS Radars



High Voltage GaAs Program

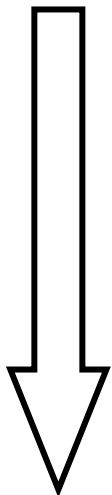


Example Cost Reduction/Performance Enhancement Opportunities

High Power Amplifier Outlook

Material	Pd (W/mm)	PAE (%)*	Insertion**	Company
GaAs	0.6	40	Current X-band Baseline	Raytheon, Triquint, MA/Com
MV GaAs	1.0-1.2	40	2005	Raytheon
HV GaAs	1.8	45	2006	TriQuint
LV GaN	3.5-5	40	2007	Raytheon, Others
HV GaN	5-7	40	2009	Raytheon, Triquint, Cree

NOW



**Near Future
“Plan for it
Now”**

LV-low voltage; MV-medium voltage; HV-high voltage

*Denotes MMIC-level efficiency

**Year at which a radar can be built with the HPAs. Passed proof of design and ready for production. Assumes radar system thermal management can handle the power density.



High Voltage GaAs Producibility Program

- Program Objectives
 - The program is a comprehensive research and development effort to achieve revolutionary, manufacturable, reliable, high voltage, high power density, X-band pHEMT devices and MMIC amplifiers with unsurpassed performance as compared with that achievable with the current pHEMT technology. The program goal is 2-3W/mm output power at the discrete device level.
- Results
 - Material experiments showing very promising results
 - Reliability data continues to look good
 - Delivered 60 functional EG7812s to China Lake
 - HV3-S variant performing at 24V and up to 30V
- Insertion: BMDS X-band Radars
- 2006 Program Completion



WBG Reliability Test Program



RF Device Reliability Test Program

- Program Objectives

- Conduct 3rd-party, independent reliability testing/verification of power amplifier discrete devices, MMICs, and packaged transmit/receive modules. The purpose is to provide MDA's Radar procurement office with an independent government verification of Contractors Device reliability to support Technology Insertion recommendations.
- Device testing conducted by NRL, NSWC-Crane, and Electro-Optics Center of Excellence
- Devices include
 - Triquent x-band HV GaAs MMICs
 - 1st generation 28V GaN devices (DARPA Phase I Deliverables)
 - Will test DARPA Phase II Deliverables (x-band GaN discrete transistors from Raytheon/CREE, Triquent, Northrop Grumman)



Hybrid Opto-Electronic Signal Processor Maturation and Evaluation



Hybrid Opto-Electronic Signal Processor Maturation and Evaluation

- Program Objectives
 - The program is a comprehensive producibility effort to achieve a revolutionary, manufacturable, and reliable Hybrid Electro-Optical Signal processor. Present program effort towards proving operation and data collection by testing the AOP while installed in the LL/MIT LexDev. Operational data collection and analysis with AOP installed in ALCOR on Kwajalein Atoll
- Results
 - Advances in Sensor manufacturing showing very promising results
 - Calibration data continues to look good
 - Testing at LexDev scheduled for mid September 2005
 - Testing at ALCOR scheduled for January 2006
- Insertion: All BMDS Radars
- 2006 Program Completion



SUMMARY

- MDA/MP Radar Program Investing in a Number of Technologies and Approaches
 - WBG High Power Amplifier Producibility and Reliability
 - Advanced Thermal Management to support HPA Insertion
 - New Architectures for T/R Modules/TRIMMS to Enhance Thermal Management/Lower Cost
 - Active and Passive Heat Extraction at TRMM Level
 - Heat Exchangers at the System Level
 - Composite Materials to Reduce Antenna Weight/Enhance Thermal
 - System Engineering Approach from HPA to Ultimate Heat Sink (air/sea)